

PERFORMANCE OF STEEL SLAG FOR WEARING COURSE COMPARED
WITH CONVENTIONAL WEARING COURSE

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This project report is dedicated to my parents
for their endless support and encouragement

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ABSTRACT

Transportation and highway orientation are going to use from sustainable material and recycling material. As the amount of disposed industrial waste material is increasing in road construction, researchers are exploring the use of waste materials which could preserve natural resources and save the environment. One of these sustainable materials is Steel-furnace slag, which is a synthetic aggregate produced as a consequence of the electric arc furnace (EAF). Steel slag was select due to its characteristics, which are almost similar to conventional aggregates, and the fact that it is easily obtainable as a by-product from the steel industry. The same gradations of mixtures would produce using normal crushed aggregate as control samples. This project was carried out to evaluate the performance of EAF steel slag aggregate in AC 14-wearing course mix, where the conventional granite aggregate was replaced with steel slag. In addition the following mix design and performance characterization of the bituminous and aggregates (steel slag aggregates and conventional aggregates) were evaluated in this project through creep tests, Resilient modulus tests at various temperatures, texture depth, skid resistance. The bitumen 60-70 PEN was used and percentage of Steel Slag was considered 0, 30, 50 and 100% for each sample. All the mixtures with EAF Steel slag have satisfied the requisites for acceptance in the road sector technical standards, thus resulting as suitable for use in the construction of road infrastructures. Samples made from steel slag showed considerably better results than conventional aggregate. Therefore, operation of steel slag would reduce land fill, save natural resources and improve the strength of pavement to sustain a higher volume of vehicles. on the other hand, laboratory test result results illustrates better performance against deformation characteristics, skid resistance, stripping of the binder and lateral movement of material compare with conventional wearing course.

ABSTRAK

Pengangkutan dan orientasi lebuhraya akan menggunakan dari bahan mampan dan bahan kitar semula. Oleh kerana jumlah bahan buangan industri dilupuskan semakin meningkat dalam pembinaan jalan raya, penyelidik sedang mengkaji penggunaan bahan-bahan buangan yang boleh memelihara sumber semula jadi dan menyelamatkan alam sekitar. Salah satu bahan-bahan lestari ini ialah keluli-relau, yang merupakan agregat sintetik dihasilkan sebagai akibat daripada relau arka elektrik (EAF). Keluli ialah pilihan kerana ciri-ciri, yang hampir sama dengan agregat konvensional, dan hakikat bahawa ia adalah mudah diperolehi sebagai produk daripada industri keluli. Penggredan sama campuran akan menghasilkan menggunakan agregat dihancurkan adalah sebagai sampel kawalan. Projek ini telah dijalankan untuk menilai prestasi EAF keluli ialah agregat dalam AC 14- memakai campuran tertentu, di mana agregat granit konvensional telah digantikan dengan keluli ialah. Selain reka bentuk campuran berikut dan pencirian prestasi bitumen dan agregat (agregat ialah keluli dan agregat konvensional) telah dinilai dalam projek ini melalui ujian rayapan, ujian modulus Berdaya Tahan pada pelbagai suhu, kedalaman tekstur, rintangan tergelincir. Bitumen 60-70 PEN telah digunakan dan peratusan Keluli Ialah dianggap 0, 30, 50 dan 100% untuk setiap sampel. Semua campuran dengan EAF Keluli Ialah telah memenuhi syarat untuk penerimaan dalam piawaian teknikal sektor jalan raya, sekali gus sesuai untuk digunakan dalam pembinaan infrastruktur jalan raya. Sampel dibuat daripada keluli ialah menunjukkan keputusan yang jauh lebih baik daripada agregat konvensional. Oleh itu, operasi keluli ialah akan mengurangkan pengisian tanah, menjimatkan sumber semula jadi dan meningkatkan kekuatan turapan untuk mengekalkan jumlah yang lebih tinggi pada kenderaan. Sebaliknya, keputusan hasil ujian makmal menunjukkan prestasi yang lebih baik terhadap ciri-ciri rekabentuk, rintangan tergelincir, pelucutan daripada pengikat dan pergerakan sisi bahan dibandingkan dengan kursus pemakaian konvensional.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	x
	LIST OF FIGURES	xi
	LIST OF ABBREVIATION	xiii
1	INTRODUCTION	1
	1.1 Background of Study	1
	1.2 Problem statement	2
	1.3 Objectives	3
	1.4 Significance of study	4
	1.5 Scope of study	4
2	LITERATURE REVIEW	6
	2.1 Introduction	6
	2.2 Overview of global application of steel slag	7
	2.3 Introduction of steel slag	8
	2.4 Production of steel slag	9
	2.5 Benefits of steel slag	11
	2.6 Properties of steel slag	12
	2.6.1 Physical and chemical properties	13
	2.6.2 Mechanical Properties	14

2.7	Effect of steel slag on pavement Industry	16
2.7.1	Stiffness	16
2.7.2	Fatigue	16
2.7.3	Rutting	16
2.7.4	Resilient Modulus due to Ageing	17
2.7.5	CBR	19
2.7.6	Moisture	19
2.7.7	Skid Resistant	19
2.7.8	Specific gravity	21
2.7.9	Creep	22
3	METHODOLOGY	23
3.1	Introduction	23
3.2	Selection of material	25
3.3	Sieve Analysis	25
3.4	Specific Gravity	27
3.4.1	Specific Gravity and Water Absorption of Coarse Aggregate	28
3.4.2	Specific Gravity and Water Absorption of Fine Aggregate	29
3.5	Sample Preparation and Mix Design Laboratory Tests	30
3.5.1	Marshall Mix Design	31
3.5.2	Theoretical Maximum Density	34
3.5.3	Bulk Specific Gravity of Marshall Mix Design Specimens	36
3.6	Data Analysis	38
3.6.1	Voids in Mineral Aggregate (VMA)	38
3.6.2	Air Void in the Compacted Mix (VTM)	38
3.6.3	Void Filled with Bitumen (VFB)	39
3.6.4	Marshall Stability and Flow Test	39
3.6.5	Determination of Optimum Bitumen Content (OBC)	42
3.7	Resilient Modulus Test	42
3.8	Asphalt Permanent Deformation or Creep Test	44

3.9	Sand Patch Test	46
3.10	Skid Resistance Test	49
4	RESULTS AND DISCUSSION	51
4.1	Introduction	51
4.2	Materials Preparation	51
4.3	Marshall	52
4.4	Resilient Modulus	52
4.5	Creep Test	54
4.6	Mean Texture Depth	55
4.7	Skid Resistance	56
5	CONCLUSION	58
5.1	Conclusions	58
	REFERENCES	60

LIST OF TABLES

TABLE NO.	TITLE	PAGE
2.1	Comparison of physical properties between steel slag and granite	14
2.2	Chemical, physical and mechanical properties of steel slag	15
3.1	Shows the number of required sample for this project	24
3.2	Gradation Limits for Asphaltic Concrete AC14 (JKR 2008)	25
4.1	Shows the results of Marshall Tests conducted	52
4.2	Resilient modulus results for ACW14	53
4.3	Data of creep test for different percentage steel slag in ACW 14	54
4.4	Shows the results of sand patch test	56
4.5	Illustrates of skid resistance in different mixes	57

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
2.1	Electric-arc furnace steelmaking and ladle refining process.	11
2.2	Axial strain versus number of load cycles for SMA Mix with steel slag filler	17
2.3	comparing between steel slag and conventional wearing course in resilient modules	18
2.4	Comparison of different asphalt concrete mixes in terms of skid numbers (Asi, 2007)	21
2.5	Illustrates performance of steel slag and conventional wearing course in creep test	22
3.1	Typical illustration of methodology by flow chart	24
3.2	Mechanical Sieve Shaker	27
3.3	Apparatus used for Specific gravity test	29
3.4	Sample Preparation for Specific Gravity of Fine Aggregate	30
3.5	Compaction Hammer	31
3.6	Specimen Mold and Blended HMA	34
3.7	TMD Test Machine	36
3.8	Bulk Specific Gravity of Marshall Mix Design Specimens	37
3.9	Machine for Flow and Stability Test	40
3.10	Samples were submerged in the Water at 60oC within 30 to 40 Minute	41
3.11	Specimen were Place into the Loading Apparatus Position	44
3.12	Fixing for creep test	45
3.13	Apparatus and material used for Sand Patch Test	47
3.14	Sand Patch Test of AC 14 Asphalt Concrete Mixes	48
3.15	British Pendulum Skid Resistance Teste	49

4.1	Resilient modulus for ACW 14	53
4.2	Illustrates performance of steel slag in Creep test (deformation) for ACW 14	54
4.3	Illustrates performance of steel slag in Creep test (Strain %) for ACW 14	55
4.4	MTD of different asphalt concrete mixes	56
4.5	Graphical representation of skid resistance of different mixes	57

LIST OF ABBREVIATIONS

AASHTO	-	American Association of State Highway and Transportation Officials
ASTM	-	American Society for Testing and Materials
JKR	-	Jabatan Kerja Raya
TMD	-	Theoretical Maximum Density
UTM	-	Universal Testing Machine
EAF	-	Electric Arc Furnace
BOF	-	Basic Oxygen Furnace
SS	-	Steel Slag
HMA	-	Hot Mix Asphalt
OBC	-	Optimum Bitumen Content
BS	-	British Standard
ACV	-	Aggregate Crushing Value
LAVV	-	Los Angeles Abrasion Value
AIV	-	Aggregate Impact Value
MTD	-	Mean Texture Depth

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Nowadays the topic of steel slag is one of the most important issues especially in transportation and highway. The molten slag flows from the furnace into a pit area where it solidifies. The slag consists principally of a fused mixture of oxides of calcium, silica, iron, alumina and magnesia. Other benefits of using steel slag in asphalt concrete include the recycling of a waste product, thus reducing the volume of material placed in Oregon landfills. Steel slag, as waste material of steel production, has been used widely in road construction because it has high density and hardness similar to those of coarse aggregates.

In general conditions, steel slag aggregates can replace natural aggregates in approximately every situation. The exemption to this is where the density of the aggregate is a crucial design consideration as in cement (Holliday & Crofton-atkins, 1997).

Hot mix asphalt (HMA) concrete is a combination of aggregate and asphalt cement. The aggregate acts as the structural frame of the pavement and the asphalt cement as the glue of the mixture. The mineral aggregate, including coarse and fine particles in asphalt paving mixtures, encompasses approximately 90% of volume of HMA (Ahmedzade & Sengoz, 2009). Somehow the properties of the aggregate have straight and considerable effect on the performance of asphalt pavements.

The HMA industry has been pressured in recent years to add in a wide variety of waste materials into HMA pavements(Kamboozia, 2012).

The resulting large quantities of slags produced and their potential impact on the environment have encouraged materials scientists and civil engineers to explore technically noise, cost-effective and environmentally acceptable use of this material in civil and highway construction. Steel slag is industrially-produced artificial aggregate which, after suitable treatment, constitute an excellent material for manufacture of wearing course in the road construction industry(According to NR2C(2008), n.d.). The manufacture and its employ are friendly to the environment while contributing in the manufacture of safer highway. Somehow the most destructive effects on construction of road especially wearing course can be to consist fatigue, rutting, skid resistance, and texture depth.

Steel-slag is a byproduct of the steel industry, and is reported to exhibit great potential as a replacement for natural aggregates in road construction. Steel-slag is a waste material that can be recycled as a road construction material. Steel-slag aggregates have been reported to retain heat considerably longer than natural aggregates. In other hand the heat retention characteristics of steel-slag aggregates can be advantageous for HMA construction, as less gas (energy) is used throughout the execution of asphaltic concrete works. Based on high frictional and abrasion resistance, steel-slag is used commonly in industrial roads, intersections, and parking areas where high wear resistance is required (Ahmedzade et al., 2009).

1.2 Problem statement

Most of the aggregates are mined material, which lead towards the reduction of natural resources. Specifically the countries having limited resources of aggregate are in trouble, and thinking about to save their assets for their future generations. On the other hand, a large area of land is being utilized for the disposal of solid waste, producing by Industries, residential, commercial and other similar sources. In this study will speak and compare the specifications conventional design and steel slag

design, that the resilient module in steel slag mix design is higher than conventional mix design. Also the conventional mix design wearing course is so poor toward compare steel slag mix design, steel slag design with excellent interlock aggregate has considerable resistance on rutting and also steel slag has greater cohesive strength compare with conventional mix design

The rapid increase in traffic volume, heavy loading and environmental impact causes early damages to pavement, such as:

- inadequate skid resistance
- deformation of aggregates
- inadequate macro texture

The most important deformation and deteriorations of asphalt hot mix design can be fatigue, rutting, creep the materials, poor skid resistance for a crossing heavy vehicles and repeated of them. Because so performance of asphalt mix design always has been steady resistance about this deterioration, in the other hand uses from new material in construction of road such as steel slag especially in wearing course can help to goes up of resistance wearing course.

1.3 Objectives

The aim of this study is to acquire sufficient knowledge of the characteristics of (EAF) steel slag as an aggregate for the design of HMA.

- To evaluate the use of different percentage of steel slag comparing with the replacement of the natural aggregates in wearing course in terms of texture depth, creep, resilient modules and skid resistance.

- To obtain a best HMA for wearing course and determine the feasibility of using steel slag aggregate in ACW14 by a suitable proportion of steel slag from the electric arc furnace (EAF), the natural aggregate and the bitumen binder.

1.4 Significance of study

From the study, the feasibility and performance of ACW 14 by using steel slag as aggregate replacement can be obtained. From the economic point of view, utilization of steel slag as road construction aggregate may reduce the cost of extracting and processing naturally occurring aggregates. The industry producing steel may also reduce their cost for treating and disposing the large number of steel slag stockpiles. In road construction, economic factor had played a major role to decide the qualities of pavement. Hundreds of millions Ringgit Malaysia allocated for road construction and maintenance work for every year. So when the performance of pavement may be increased, the maintenance cost for pavement may also reduce. From environment impact, utilization of steel slag aggregate may directly reduce on naturally occurring aggregate and the number of raw material extracting projects. Incorporating steel slag in road construction also can reduce the use of landfill area.

1.5 Scope of study

The scope of the study will be focus the performance of the Stone Mastic Asphalt (SMA) when aggregate is replaced with 0%, 30%, 50% and 100% steel slag. The steel slag were used is from Purata Keuntungan Sdn. Bhd located at Pasir Gudang Laboratory Marshall mix design have been done in this study and all mix design was referred from JKR/SPJ/2008. The bitumen were be used is from 60/70. For control mix design, the aggregate were got from MRP Quarry locate at Ulu Choh, Pulau. The test that doing in this research is resilient modulus, creep test, skid resistance and texture depth. And then, the result will be compare with the control mix that used the common aggregate. This study only limited to laboratory test and not considered

field test. All the test and laboratory work were performed at Highway and Transportation Laboratory, Universiti Teknologi Malaysia.

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